TISCIA 29, 3-10

RELATIONSHIP BETWEEN VEGETATION AND SOIL ON THE NORTHEASTERN SLOPE OF THE FEHÉR-SZIRT (WHITE CLIFF) OF KESZTÖLC

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Penksza, K., Barczi, A., Benyovszky, B. M., Möseler, B. M., Birkenheuer, V. and Szabó, T. (1995): Relationship between vegetation and soil on the northeastern slope of the Fehér-szirt (White cliff) of Kesztölc. - Tiscia 29, 3-10.

Abstract. In 1993-1994, the forest vegetation of the northeastern slope of the Fehér-szirt (White Cliff) near Kesztölc, Hungary, has been investigated by transect method. Along a 400 m transect, phytosociological relevés were taken in 20×20 m adjacent plots through the *Mercuriali-Tilietum* Zólyomi et Jakucs 1958, *Querco petraeae-Carpinetum* Soó et Pócs (1931) 1957 and the *Melitti-Fagetum* Soó 1962. Along the transect studied specific soil parameters were analyzed: moisture content, bulk density, humus content, pH (H_20 and KCl), lime content ($CaCO_3$), nutrient regime (N,P,K), texture, 'sticky point according to Arany' (K_A) and hygroscopy. According to the phytosociological data, no clear-cut border can be drawn between the associations. Changes in the vegetation correlate with the physical properties of the soil: more mesophilous beech forest on the Humic Cambisol formed from loess with a higher water capacity and the hornbeam-oak forest on Chromic Cambisol formed from sandy parent material with a lower water capacity.

Keywords: Soil, vegetation, transect.

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Introduction

The transect-method is very suitable for the investigation of two adjacent associations with continuous transitions without a clear line of demarcation (Van der Valk and Danis, 1976; Katona and Tóthmérész, 1984; Mészáros et al., 1981; Molnár, 1989; Tóthmérész, 1993). By that method, gradual changes in species composition of the vegetation due to specific ecological factors - i.e. altitudinal or humidity gradients - can be described (Whittaker, 1956; Whittaker and Niering, 19630; Auerbach and Shmida, 1993). Although these authors have used similar methods to investigate complete mountains, the transect method is useful for smaller areas as well. The present investigations will examine the relationship between soil parameters and remarkable transitions of the White Cliff forest vegetation where the segregation of different associations are blurred (Kovács, 1964; Marrs and Proctor, 1979). These investigations will supplement previous studies on the relationship between soil and vegetation of the White Cliff of Kesztölc by Kovács-Láng (1966, 1971) and Draskovits and Kovács-Láng (1968) which dealt with the rocky grasslands of the steep SW facing slope.

This study is directed to the question whether any relationship exists between soil and vegetation characteristics in adjacent forest associations where segregation borders are blurred.

Methods

The investigated area is the smaller part of the westernmost section (Kétágú-hegy) of the Pilis Mountains in Hungary (Bulla, 1962). Soil studies and vegetation analysis were carried out on its northeastern facing slope on 14 October 1993, 25 March, 28 April and 6 June 1994 (Fig. 1).

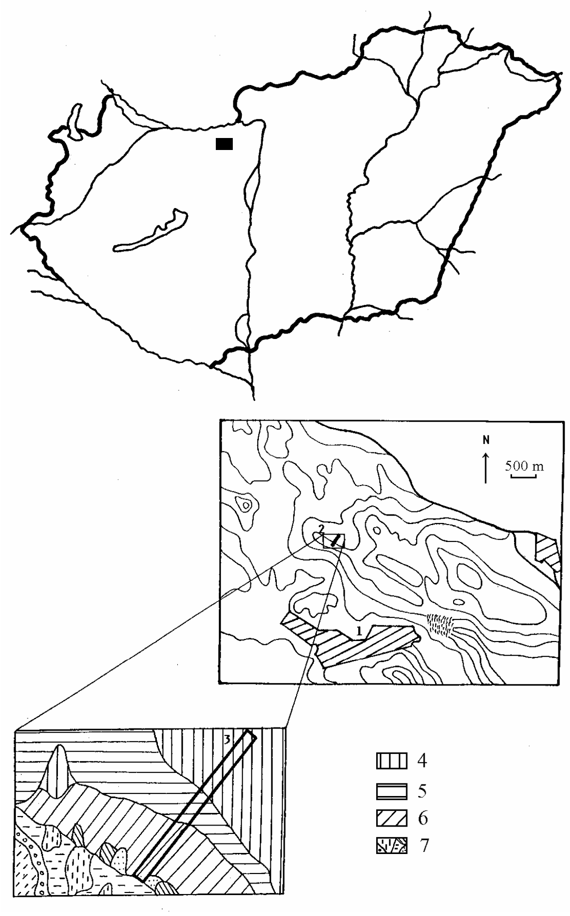

Figure 1. The investigated area. 1: Kesztölc, 2: Fehér-szirt (White Cliff), 3: transect, 4: Melitti-Fagetum, 5: Querco petreae-Carpinetum 6: Merculiali Tilietum 7: Grasslands and shrubforests complex

Close to the peak of the Fehér-szirt (White cliff) the *Orno-Quercetum* Horánszky, Jakucs et Zólyomi 1958 or the *Mercuriali-Tilietum* Zólyomi et Jakucs 1958 are found followed by *Querco petraeae-Carpinetum* Soó et Pócs (1931) 1957 and *Melitti-Fagetum* Soó 1962 on the lower slopes (Penksza, 1993).

On the northeastern slope of the hill it is noticeable that between 250 and 350 m asl. the *Melitti-Fagetum* is connected with the *Querco petraeae-Carpinetum* zone.

The phytosociological relevés were taken along a 400 m long transect consisting of 20 × 20 m adjacent plots (Whittaker, 1967; Krebb, 1983). The transect was placed across *Mercuriali-Tilietum*, *Querco petraeae-Carpinetum* and *Melitti-Fagetum*. Each species was documented by its cover percentage. The phytosociological table shows the mean cover of relevés in three dates.

The syntaxonomical ranks and nomenclature of the species are after Simon (1992). Mean W values were calculated according to Borhidi (1993). The syntaxonomical nomenclature is after Soó (1980), that of the soils is in accordance with Stefanovits (1956, 1961, 1992) and the FAO standards.

First the soils of the area were sampled using the Pürckhauer-sampler technique (Benzler et al., 1982), by which a 2-3 cm in diameter and 1 m long soil core was taken. This method is suitable for separating the genetic soil types, choosing the most characteristic sampling plots and a previous investigation of the selected plots. Apart from this, information on the thickness of the surface soil was obtained on the spot, too. Soil cores were taken in the phytosociological plots, more cores were taken in the contact zone between different soil types. These profiles were pre-investigated in the field, and the different layers were sampled for further analysis. Physical and chemical properties of soil samples were examined according to the prevalent standard (Buzás, 1988, 1993). The investigations included the following parameters: moisture content, bulk density, humus content, pH (H_20 and KCl), lime content ($CaCO_3$), nutrient regime (N,P,K), texture, 'sticky point' (according to Arany, K_A), hygroscopy.

Results

Table 1 contains the coverage values of the occurring species in the phytosociological relevés. The species are enumerated by cenological groups.

Fig. 2 shows species (including their cover values), which are restricted to certain associations. *Quercetea pubescentis-petraeae* species which are characteristic species of the shrub forest and the xerophytic oak forest were found only in the first 6 plots and have higher cover-percentage only in the first 3 plots. *Geranium lucidum*, characteristic species of the *Mercuriali-Tilietum* association could only be found in relevés no. 3-5, probably the most typical strip of the association. *Tilia platyphyllos*, which is a characteristic tree species of the *Mercuriali-Tilietum* occurred in the hornbeam-oak forest (*Querco petraeae-Carpinetum*), as well. The other *Tilia* species, *Tilia cordata* which is

Table 1. Coverage values of occuring species in percentage

Relevés (no.)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A																				
Querco-Fagetea species																				
Fraxinus excelsior	10	10	20	10	15	20		15	10	5										
Quercus petraea	20	15	10		20	5	10	30	10	5	5	10				10	5	10		
Acer campestre		5		15	15										15					
Tilia cordata									10		30	15	20	35	30	5	25	15	10	25
Acer platanoides												15						20		
Carpinion-Betuli species																				
Carpinus betulus						5	5			10	30	40								
Fagion medio-europaeum species																				
Tilia platyphyllos	30	30	25	40	30	25		5	10	40										
Quercetea pubescenti-petraeae species																				
Quercus pubescens	5												10							
Quercetalia pubescentis species																				
Quercus cerris	5					3		10	15											
Ceraso-Quercetum pubescentis species																				
Cerasus mahaleb	10	5																		
Fagetalia species																				
Fagus sylvatica		5											60	40	40	60	45	40	60	50
B																				
Quercetea pubescenti-petraeae species																				
Cornus mas	50	30	40	40	30	25	20	20		5										
Fagion medio-europaeum species																				
Tilia platyphyllos	10	10	10	15	10	5		10	30	10	10									
Querco-Fagetea species																				
Sorbus torminalis						3														
Staphylea pinnata					10			5	10	5	10	5	10	10	5	2	3	1	3	3
Lonicera xylosteum									5				5	3		3				
Acer platanoides									2		2	3		3		3	3	2		2
Tilia cordata								15	10	20	30	10		10	5	5	10			
Fraxinus excelsior							30	10	5	5	5									
Acer campestre							10	3						3						
Viburnum lantana														2						
Prunion spinosea species																				
Crataegus monogyna		5						5		5										
Fagetalia species																				
Fagus sylvatica													5							
Acer pseudo-platanus												5	2							
Ulmus glabra										5	5	5	2							
Sambucetalia species																				
Sambucus nigra													2							
Carpinion-Betuli species																				
Carpinus betulus							10										3	5		5
C																				
Querco-Fagetea species																				
Ficaria verna	5	1		12	18	12	15	15	15		2	2	2			5	2		3	20
Geum urbanum	3	1	1		2	1		1	1											
Veronica hederifolia	17	20	12	15	22	12	35	3	3		5									
Moehringia trinervia	15	15	10	9	4	4			2		2	2	2	5	2	3				
Alliaria petiolata	8	6	13	8	4	4	3	5	1	5	5	1	3		4	4	3	2	4	2
Geranium robertianum	8	11	8	13	12	18	12	16	10	23	33	16	4	1						
Cystopteris fragilis			3		5	2														
Bromus benekenii		7	10	4	7	2	6	5		1		2	2	2		2	2	5		5
Viola odorata	5	2	5	5	5		5	5	5	1							2			1
Lilium marthagon					1										1	2			1	
Melica uniflora	10	32	27	35	15	5	30	25	22	5	5	5	3	5	5	5	5	5	3	5
Veratrum nigrum				11	2	2	1	1	5	1				1						
Poa nemoralis		7	5		4	1		1							2					
Galium schultezii					5			2	3	3		5		1						

Table 1. Continued.

Relevés (no.)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Dactylis polygama	27	7	9	10						3			3				1			
Veronica chamaedrys			2											3						
Galium mollugo	5																			
Lapsana communis	3																			
Viola sylvestris										2		2	2			4	4	3	2	5
Heracleum sphondylium							1		2			3	2		3		3			
Viola alba														10	1	1	1	1	2	
Melica nutans														3	3	1			7	
Campanula rapunculoides														5	10	5			2	
Lathyrus niger																1				
Brachypodium sylvaticum															2					
Mycelis muralis													2							
Scrophularia nodosa									1								2	2		1
Clematis vitalba														1						
Fagetalia species																				
Lamium maculatum	15	13	13	9	30	30	12	20	8	33	31	16	2		10		5	10	5	13
Mercurialis perennis	13	5	15	5	9	9	12	5	8	5	2	3	23	22	13	8	4	22	20	20
Corydalis cava	2	4	4	3	12	3	7	17	22	3	12	15	1		3	5	5	12	7	15
Corydalis solida	10	7	4	3	7	3	15	7	5	12	7	5	1		3		2	4	4	4
Isopyrum thalictroides			1			1												1		
Glechoma hirsuta		12	15	13	15	13													10	20
Gagea lutea	3	8	15	12	6	5	8	5												
Galanthus nivalis	8	21	22	22	22	4	8	8	5	3				3			2	3	4	3
Anemone ranunculoides	3	3	3	4	2	2	3	3	5	2	5				3	5	5	3	3	5
Hedera helix	5	5	5		3			5	3	2	3	3	5	5	3	3	2		2	2
Pulmonaria officinalis			5	5										6	6	6	6	4	4	2
Aconitum vulparia			3																	
Viola mirabilis	5	5											1	1	2				3	
Galium odoratum					4			2		5	5	5	15	8	16	10	10	5	10	10
Polygonatum multiflorum		2	1				1	5	3	2	2	2	3			5	3	1	1	3
Campanula trachelium			1	1										1						
Dentaria bulbifera							5	5	5	4	8	7	10	8	13	18	10	4	12	8
Asarum europaeum							1				3	6	15	26	13	12	8	8	8	5
Galeobdolon luteum										13	12	15	5		5		13	13	8	12
Arum maculatum								3	4	3										
Stachys sylvatica												5							2	5
Hordelymus europaeus										2	5							2		3
Lathyrus vernus										2	3			3		5				
Symphytum tuberosum																3		5		
Ranunculus auricomus																				
Alliarion petiolateae species																				
Chelidonium majus	9		2	8	5	5	1													
Chaerophyllum temulum			12	12	18	42	30	5	5	7	30				6					
Quercetea pubescenti-petraeae species																				
Cardaminopsis arenosa	18	4	15	4		4														
Arabis turrita	10	5	5	1	2															
Sedum maximum	5																			
Valeriana officinalis	4																			
Silene vulgaris	3																			
Pulmonaria mollissima							3	1			3	7	6							
Heracleum sphondylium				1																
Seslerio-Festucion pallentis species																				
Asplenium ruta-muraria	5		5		5	2														
Fagion medio-europaeum species																				
Geranium lucidum	18		5	1	14															
Asplenio-Festucion pallentis species																				
Polipodium vulgare	9		15	1																
Quercetum petraeae-cerris species																				
Campanula persicifolia		5	5	1																
Festucetalia valesiaceae species																				
Carduus collinus	5		2																	

Table 1. Continued.

Relevés (no.)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Chenopodietea species																				
Melandrium album	3								2	2										
Stellaria media		20	5	5																
Ballota nigra	3	3	5																	
Arctium lappa															2					
Bilderdikia convolvulus	2	2																		
Cirsium arvense									3	2										
Calystegietalia species																				
Galium aparine					5	5	12	15	20	10	10	6			5	4	8	28	8	18
Urtica dioica																				1
Quercetalia pubescentis species																				
Chrysanthemum corymbosum			2																	
Orno-Cotinetalia species																				
Oryzopsis virescens																				
Melittis melissophyllum								1					1	1	1	2				
Festuco-Brometea species																				
Muscari neglectum	2																			
Carpinion betuli species																				
Carex pilosa								3		4	5	10	25	33	18	23	13	15	13	25
Stellaria holostea	8		10	12	4			11	5	7	10	8	7		17		7	8	5	6
Pino-Quercetalia species																				
Hieracium sylvaticum																				
Convallario-Quercetum roboris species																				
Convallaria majalis															10	4				
Arrhenatheretea species																				
Dactylis glomerata															1					

characteristic of beech forests (*Melitti-Fagetum*), was also found in the *Querco petraeae-Carpinetum*, but missed in the *Mercuriali-Tilietum* association. *Chelidonium majus* and *Chaerophyllum temulum* as *Alliarion petiolatae* species could be found as natural components of the association owing to the high N content of the soil. *Carpinus betulus* occurred in relevés Nº 6-12, its cover is around 50% in relevés Nº 10-12. Regarding the cover percentage, as well there is an approximately 60 m long strip that can be considered as “proper” hornbeam-oak forest. The other recorded *Carpinion* species, *Carex pilosa* is not strictly bound to the *Querco petraeae-Carpinetum* association. It was found in the *Melitti-Fagetum* as well, but it attained only low cover values. *Gagea lutea*, a *Fagetalia* element is typical of the *Mercuriali-Tilietum*. *Fagus sylvatica* itself is the only *Fagetalia* species with a clear-cut border, *Asarum europaeum* and Galium *odoratum*, *Fagetalia* species likewise, occurred in the *Querco petraeae-Carpinetum*, as well.

Fig. 2 also shows the mean W-values of each plot. These values show a gradual increase from 4.2 to approximately 5. This increase is effected by former deep roads crossing that loess area establishing a certain soil solidification. The relevés no. 13-16 show decreasing values, caused by a slight increase in the number of the species of the herb layer, which are usually attached in xerophytic associations (characterized by lower W-values).

Soil sampling also remarked the diversity of the bedrock. The Triassic Dachstein limestone was uplifted to the surface in the form of standing columns close to the peak, and Lithic Leptosol is formed on it with a thin solum. Further down these soils are replaced by 30-40 cm deep black Rendzic Leptosol. From where the sandy parent material from the Pleistocene age appears Mollic Cambisols formed from sand and sandy loess make the surface more diversified.

Towards the hollow the parent material of these soils change into loess which has not been destroyed by erosion, younger than the sand but originates also from the Pleistocene. Humic Cambisols formed on the sandy parent material can be separated and are referred to as Haplic Luvisol. These brown forest soils were characterized by even, thick layers under both the beech and oak forests, so degradation caused by erosion and deposit accumulation (and thickening of the solum by this) are out of the question. Other signs of erosion (e.g. gravel bands) have not been found either.

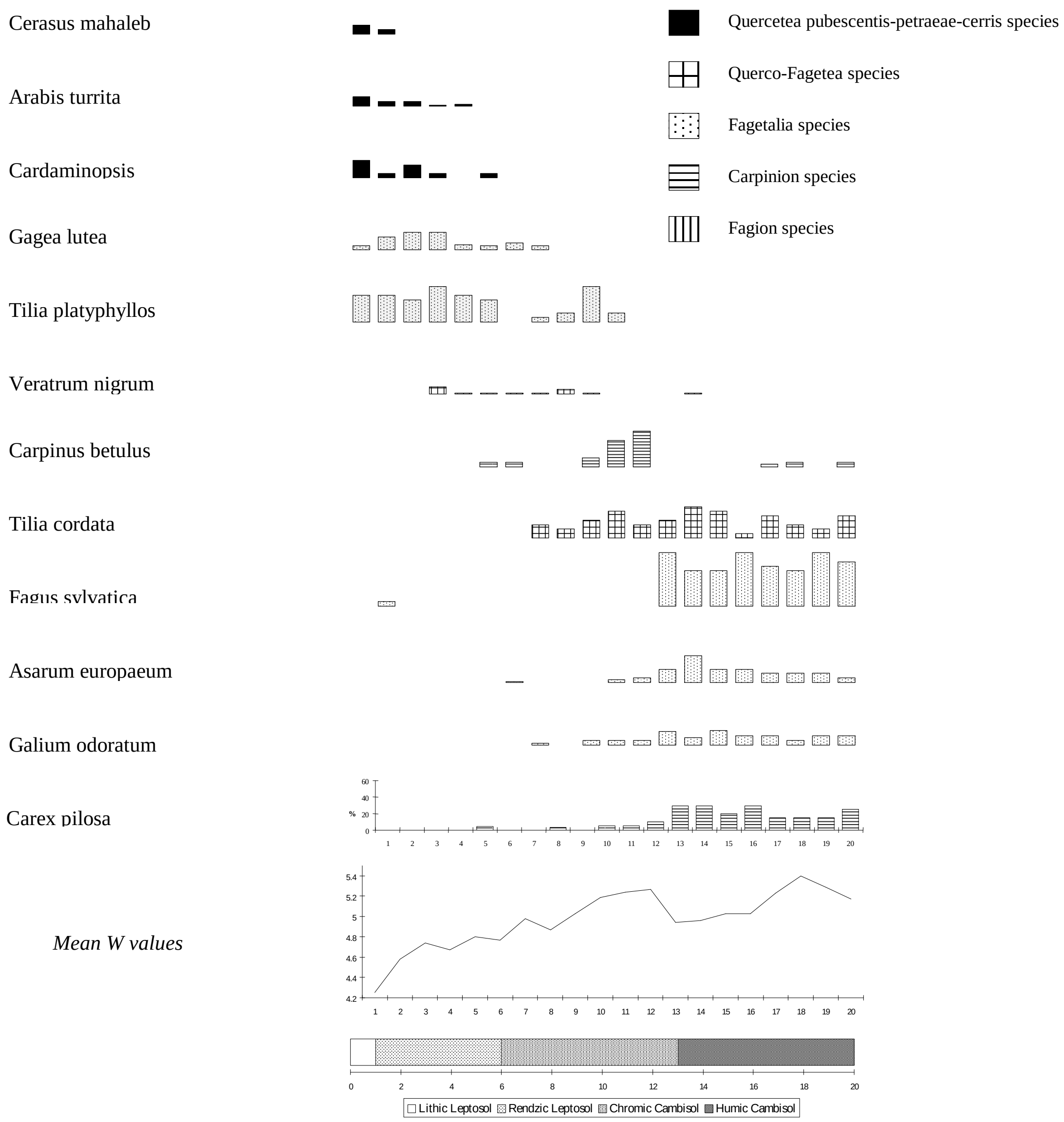

Figure 2. The distribution of selected species (%)

The pedological analysis was carried out in the laboratory to elucidate any reasons for the vegetation changes. Lithic Leptosols, Rendzic Leptosols and Haplic Luvisols differ significantly in several parameters. These changes accorded with the genetic types of the soils. Brown forest soils differed also significantly from other types of soils, but the properties of the two varieties (Humic Cambisol and Chromic Cambisol) sampled under beech and oak forests were very similar to each other, and most properties did not show significant differences (Table 2). The physical properties of these latter soils differed at the highest significance level. A clay fraction appears in the ‘B’ horizon due to the clay formation processes which are characteristic of the forest soils. The physical type of the ‘C’ horizon was in accordance with the parent material. As it is shown in table there can be significant differences between the physical types of soils (depending on the parent material) although their conditions of formation and the soil genetic processes were the same. As a result the largest difference between the varieties could be detected in the texture, hygroscopy and K_A (Table 3). It should be noted that the changes in soil types and vegetation correspond to each other and that the two types of the Humic Cambisols also changed at the border of the beech and the oak forests (see Fig. 2).

Table 2. Soil properties in the forest soil profiles by genetic horizons. K_A is the 'sticky point' according to Arany.

	Humic Cambisol			Chromic Cambisol		
	0-30 cm	30-100 cm	100-130 cm	0-30 cm	30-100 cm	100-130 cm
Humus (%)	3.31	1.15	0.71	3.42	0.97	0.64
pH (H_2O)	6.4	6.8	7.3	6.1	6.7	6.9
$CaCO_3$ (%)	0.52	0.76	19.70	0.38	0.10	1.06
K_A	40	44	36	34	33	30
NO_3-N+NH_4 (ppm)	26	11	5	24	8	4
P_2O_5 (ppm)	30	25	27	28	21	26
K_2O (ppm)	104	138	113	100	121	81

Table 3. Results regarding the physical types of the forest soils by genetic horizons. K_A is the 'sticky point' according to Arany, hy_1 is hygroscopy.

	Humic Cambisol			Chromic Cambisol		
	0-30 cm	30-100 cm	100-130 cm	0-30 cm	30-100 cm	100-130 cm
K_A	40	44	36	34	33	30
hy_1	3.7	4.2	2.1	3.3	3.2	1.4
Particle size (%)						
0.01 mm <	52	42	51	66	63	61
0.01-0001 mm	31	46	39	26	24	28
0.001 mm >	17	12	10	8	13	11

Discussion

Phytosociological results indicate that the three zones considered as associations are primarily marked by tree species. Although the species in the herb layer which are characteristic of the associations have the maximum cover within their typical zone, they also occur with lower cover in the adjacent associations. Mean W-values are character-istic and are parallel to the phytosociological results because more mesophilous associations show higher W-values.

Phytosociological results and mean W-values also correspond to the results of the soil analysis, so the changes in the soil are reflected by the changes in the vegetation. In the region close to the peak where the *Mercuriali-Tilietum* was found, Lithic Leptosol and Rendzic Leptosol were formed. Appearance of the *Querco petraeae-Carpinetum* is paralleled to brown forest soils. The brown forest soils of the hornbeam-oak forest and the beech forest (*Melitti-Fagetum*) differ. Beneath the hornbeam-oak forest Chromic Cambisol, beneath the beech forest Humic Cambisol can be found. The Hungarian nomenclature considers these soil types as one because of their similar properties. However, as shown in this study, there are some differences between these soils due to which they provide suitable conditions for different types of vegetation. Changes in the vegetation are in close relationship with the physical properties of the soil (texture, which determines the water regime of the soils), since these are the most varied of the soil parameters examined. The loamy physical type (of the soil formed beneath the beech forest from loess) can support an association with higher water demand. In the strip of the hornbeam-oak forest The Chromic Cambisol formed from sandy parent material (sand or sandy loam physical type) provide growth conditions for a slightly more xerophilous association.

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